Study of ditau production at ZEUS

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ZEUS Collaboration

INFN Firenze

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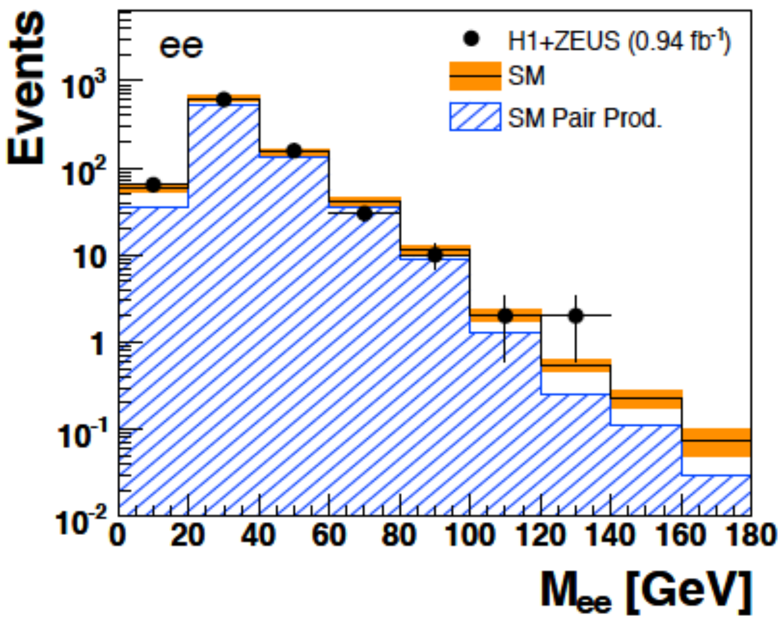
DIS 2011

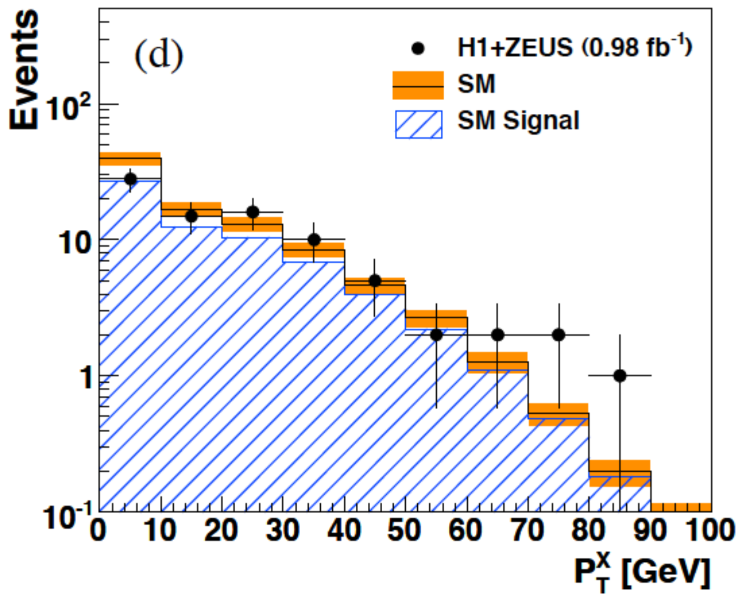
XIX International Workshop on Deep Inelastic Scattering and Related Subjects

Isolated leptons at HERA

As in every collider isolated leptons at high p_t are a signature for possible new physics beyond the SM. Long tradition at HERA:

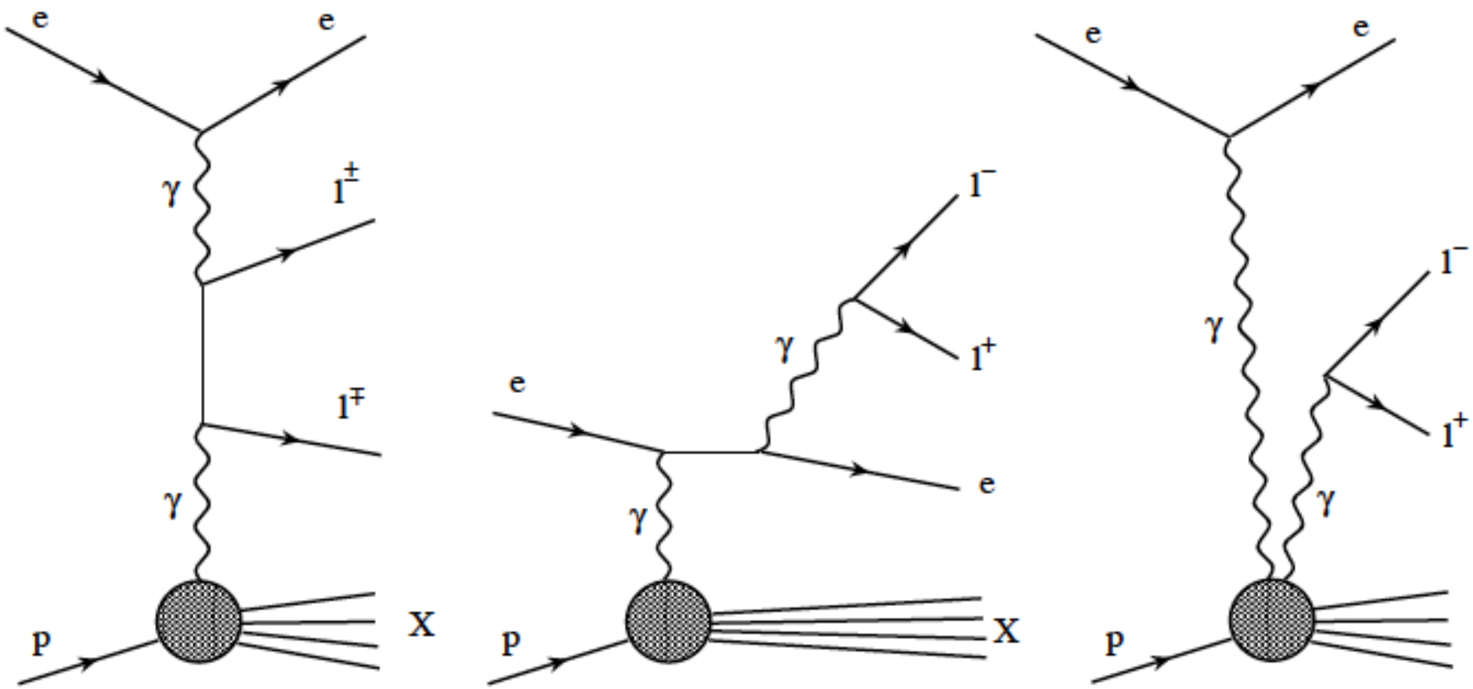


Two isolated electrons



One lepton, missing p_t and a high p_t jet

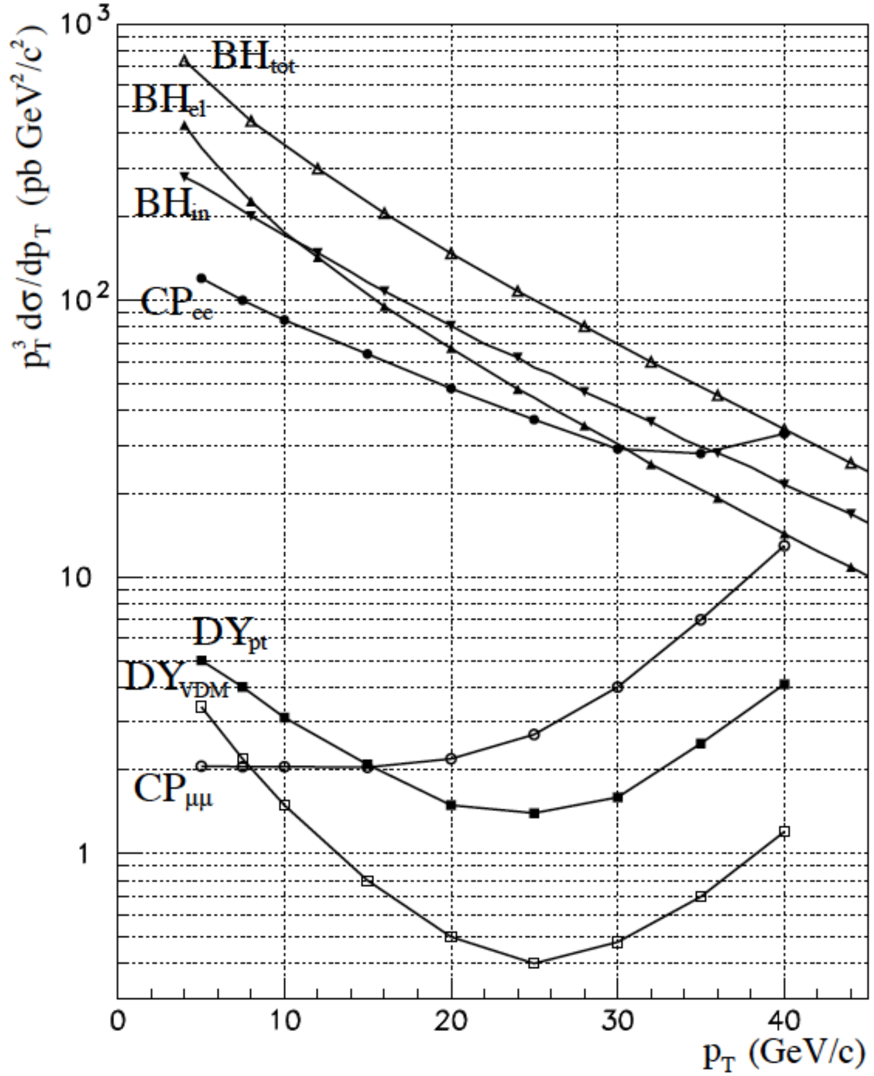
Ditau production at HERA



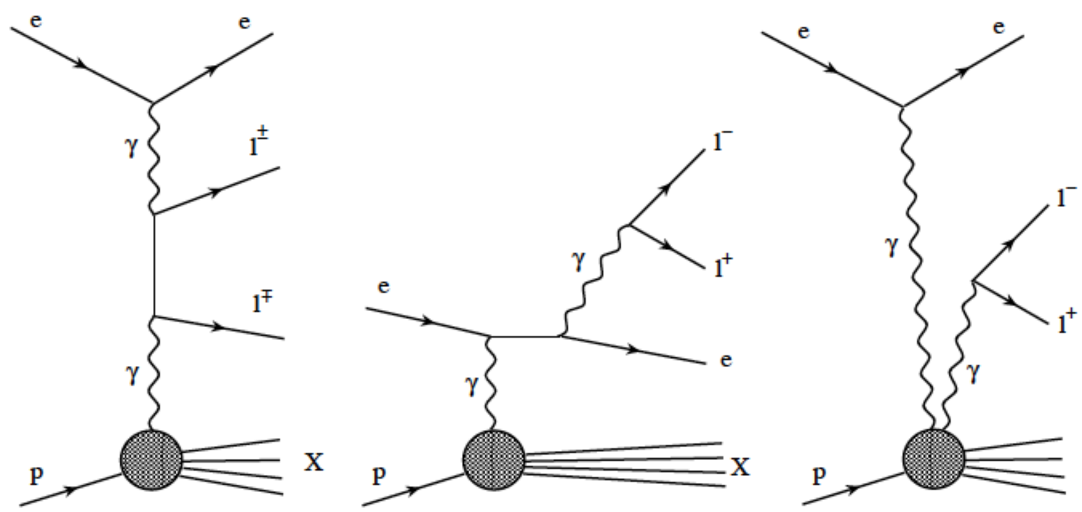
Bethe-Heitler Cabibbo-Parisi Drell-Yan

(Simulated by the GRAPE MC)

Ditau production at HERA



Strategy for Ditau production

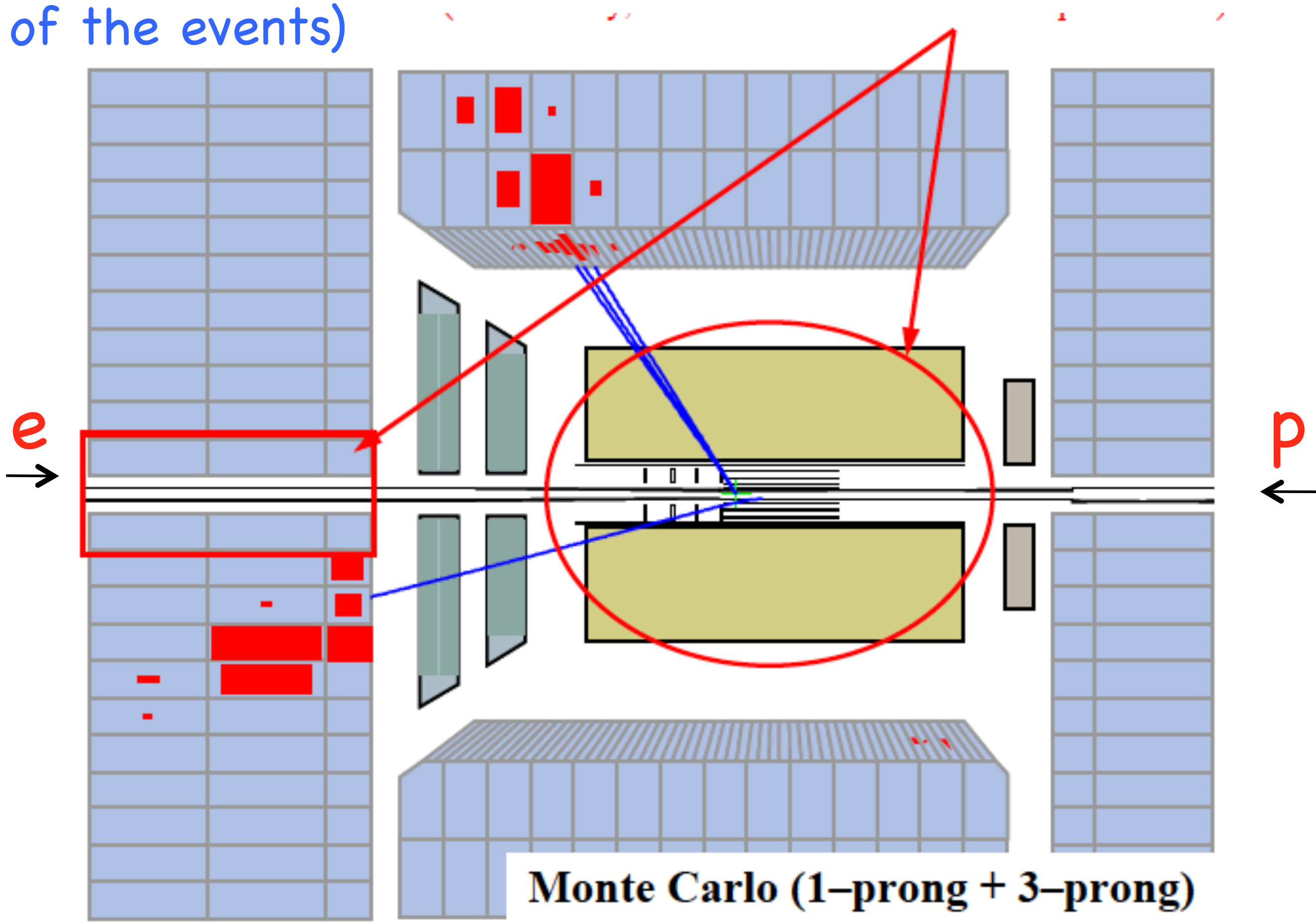


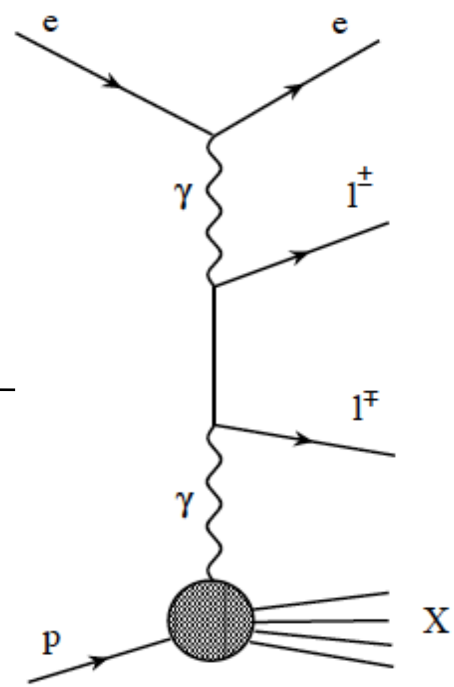
HERA II data (0.33 fb^{-1}), τ -> e,μ,h all three decays considered, in each combination but:

- no ττ -> μμ or ee, impossible to distinguish from dielectron or dimuon process
- only the „elastic" process is considered, the inelastic DIS process would be an enourmous background

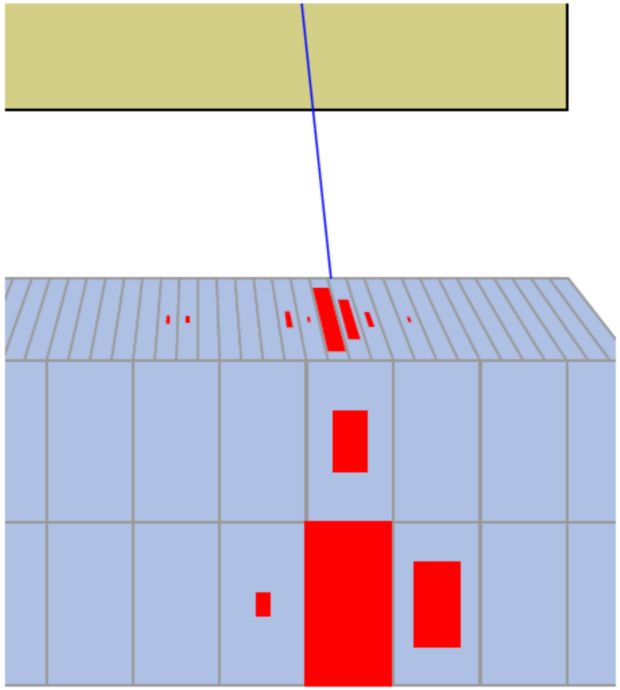
Ditau selection

Preselection: no deposit in the forward beampipe region, low multiplicity (from 2 to 7 charged tracks). Then look for two objects (e, muon or hadronic jets), and the eventually the scattered electron (1% of the events)

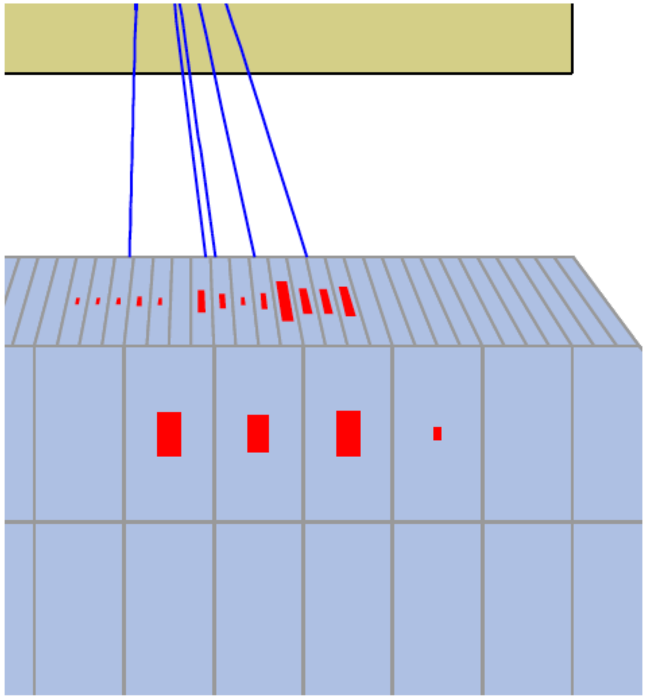




Tau jets



A tau-jet, narrow and low multiplicity



A QCD-jet, broader, higher multiplicity

Use a multivariate discrimination technique to distinguish between tau jets and QCD jets, based on 6 variables dependent on the shape of the jets

Discriminant for Tau jets

- The jet mass

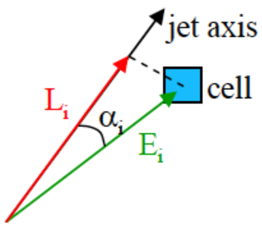
$$M_{jet} = \sqrt{(\sum_i E_i)^2 - (\sum_i p_{i,x})^2 - (\sum_i p_{i,y})^2 - (\sum_i p_{i,z})^2}$$

- The 1st and 2nd moment of the radial extension

$$Rmean = \langle R \rangle = \frac{\sum_i \{E_i \cdot R_i\}}{\sum_i E_i} \qquad Rrms = \sqrt{\frac{\sum_i E_i \cdot (\langle R \rangle - R_i)^2}{\sum_i E_i}}$$

- The 1st moment of longitudinal extension

$$Lmean = \langle L \rangle = \frac{\sum_i E_i \cdot \cos\alpha_i}{\sum_i E_i}$$

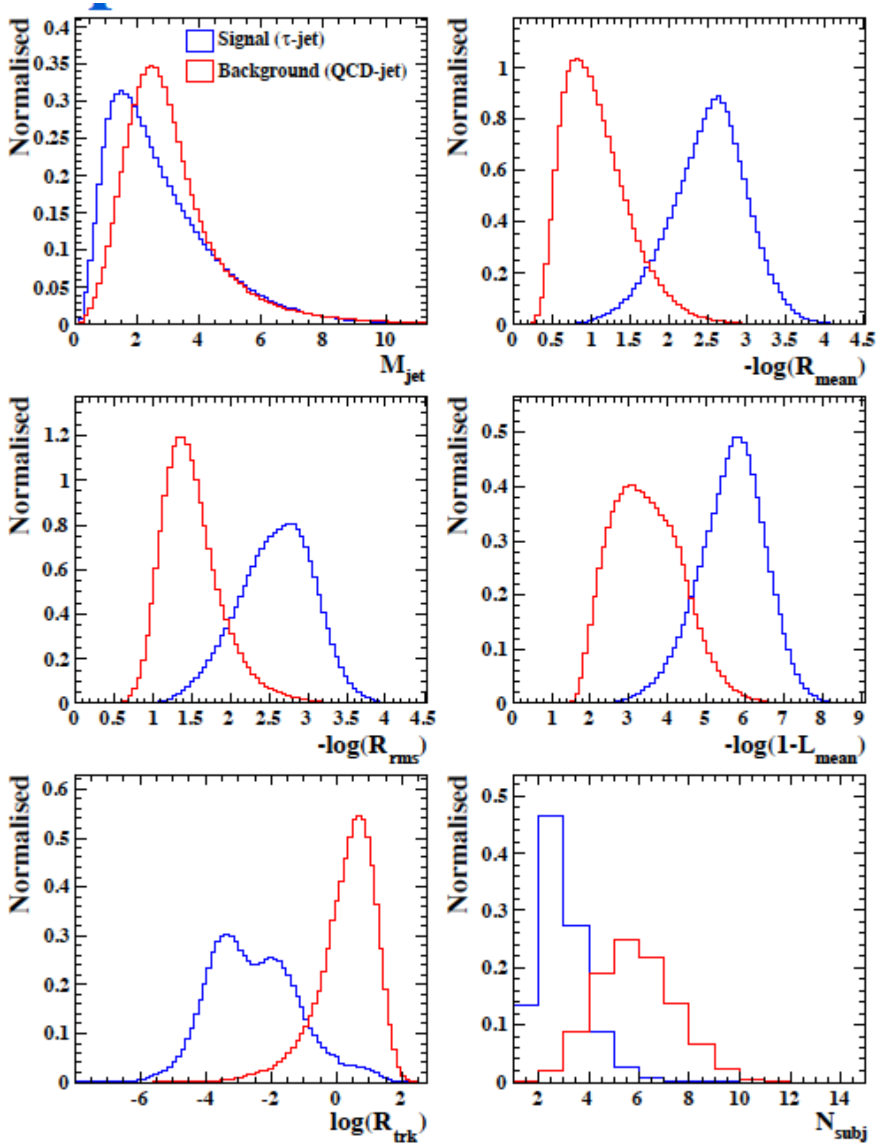


- Distance between jet axis and trks

$$Rtrk = \sum_i^{Ntrk} \sqrt{(\Delta\eta_i^2 + \Delta\phi_i^2)}$$

- $N_{subjets}$ (y_{cut}=5X10^{-4})

J. Maeda's PhD thesis, Tokyo University



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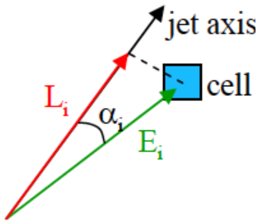

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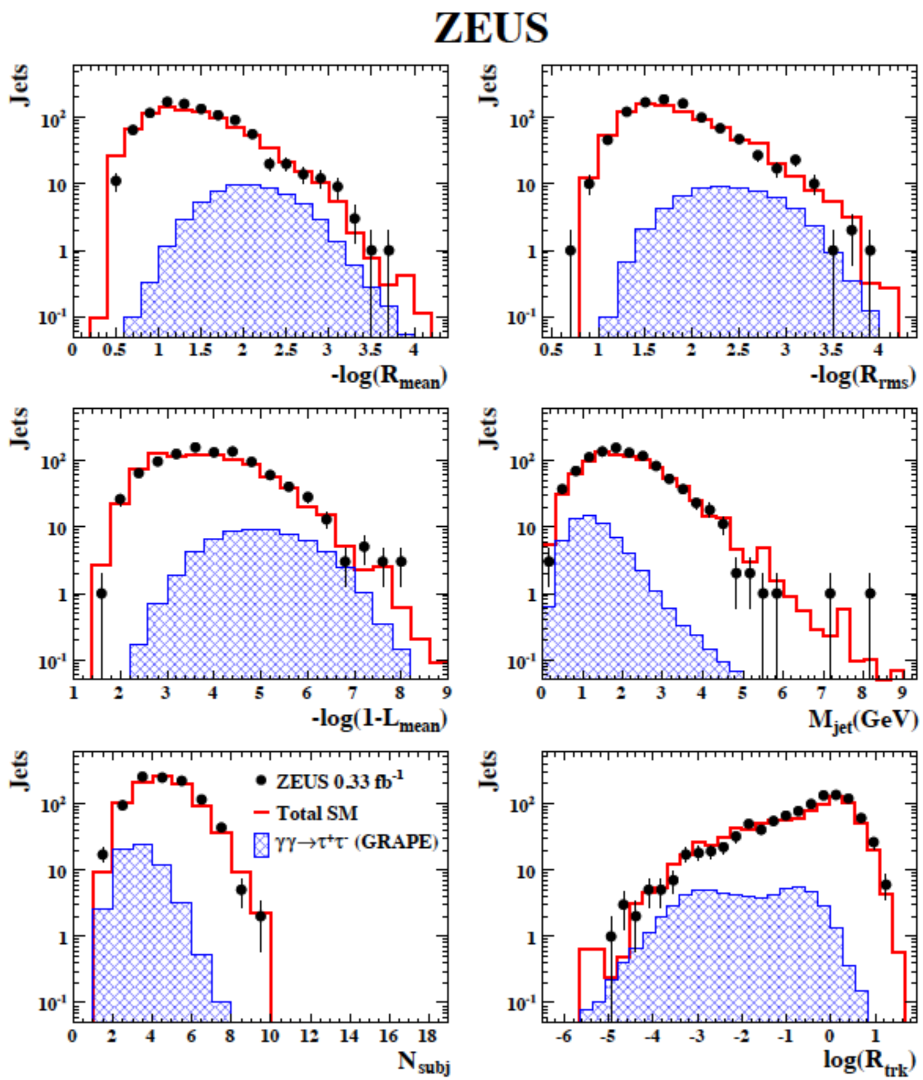


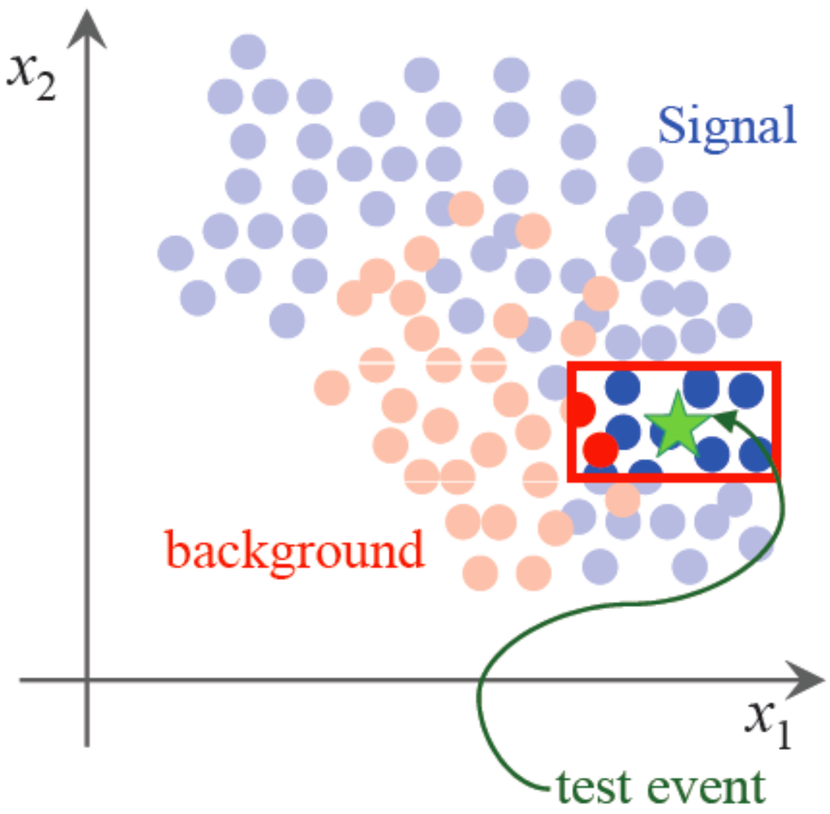
Discriminant for Tau jets

Calculate a discriminant in a 6-dimensional box:

$$\mathcal{D}(\vec{x}) = \frac{\rho_{\mathrm{sig}}(\vec{x})}{\rho_{\mathrm{sig}}(\vec{x}) + \rho_{\mathrm{bkg}}(\vec{x})}$$

D->1 for signal, D->0 for background

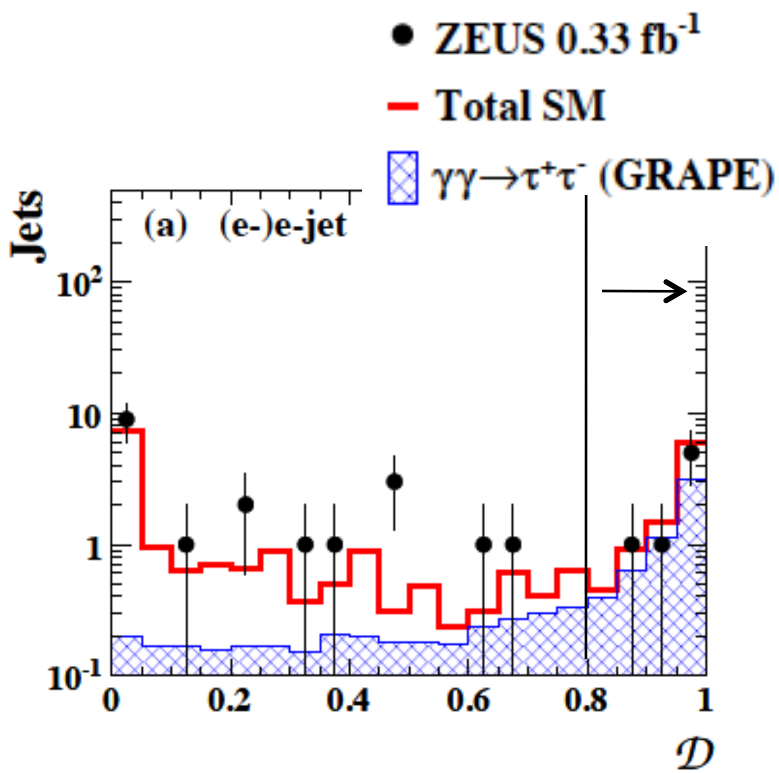
Select jets with D>0.8

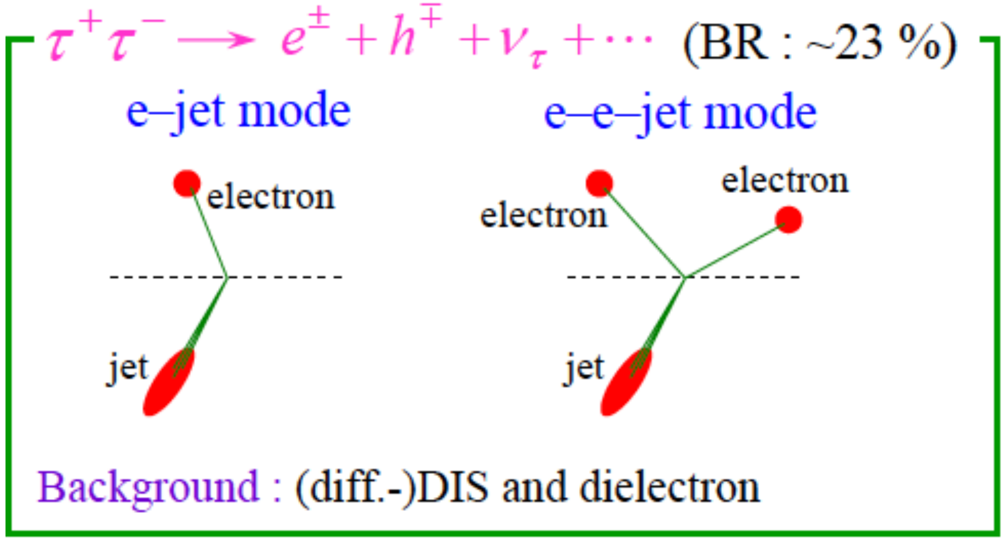


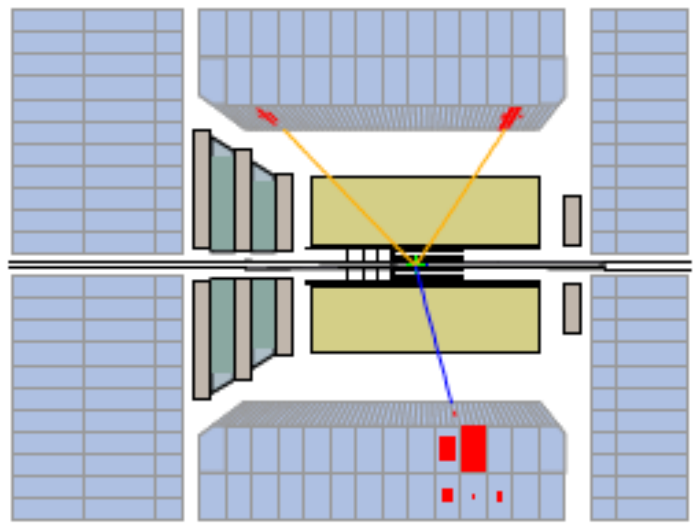
T. Carli and B. Koblitz NIM A501 (2003) 576.

(e)-e-jet channel

P_t^e > 2 GeV, 17°<θ_e<160°,
P_t^{jet} > 5 GeV, |η|<2
Main issue: DIS backg. In e-jet, e opposite charge to the beam

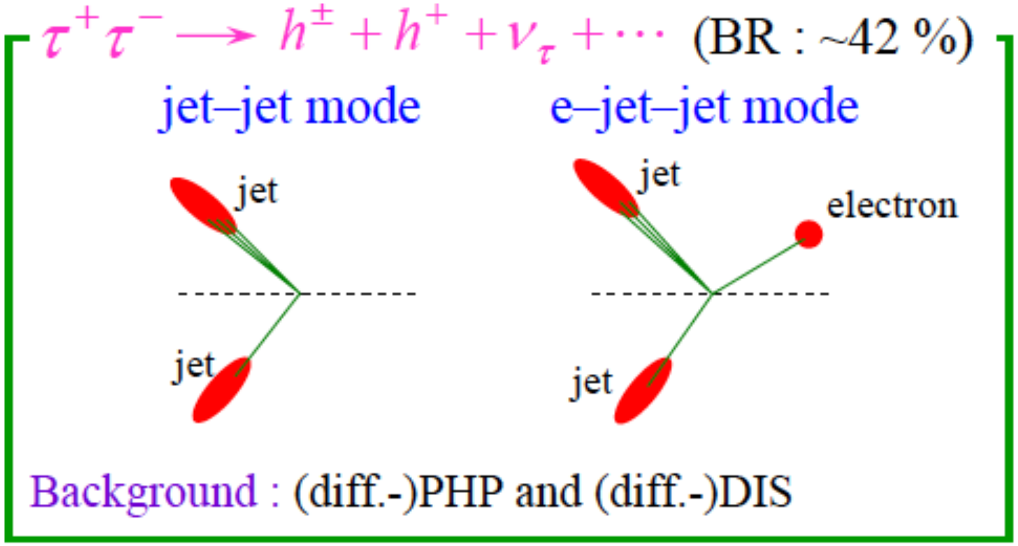


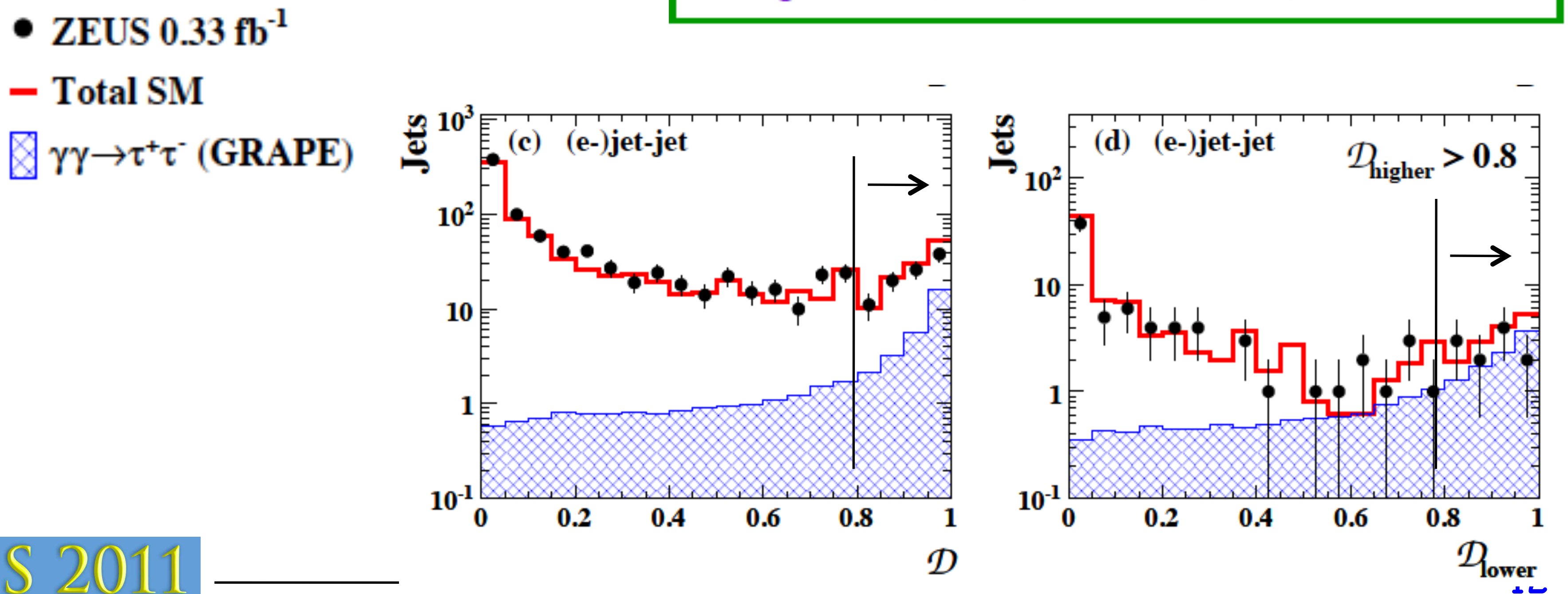




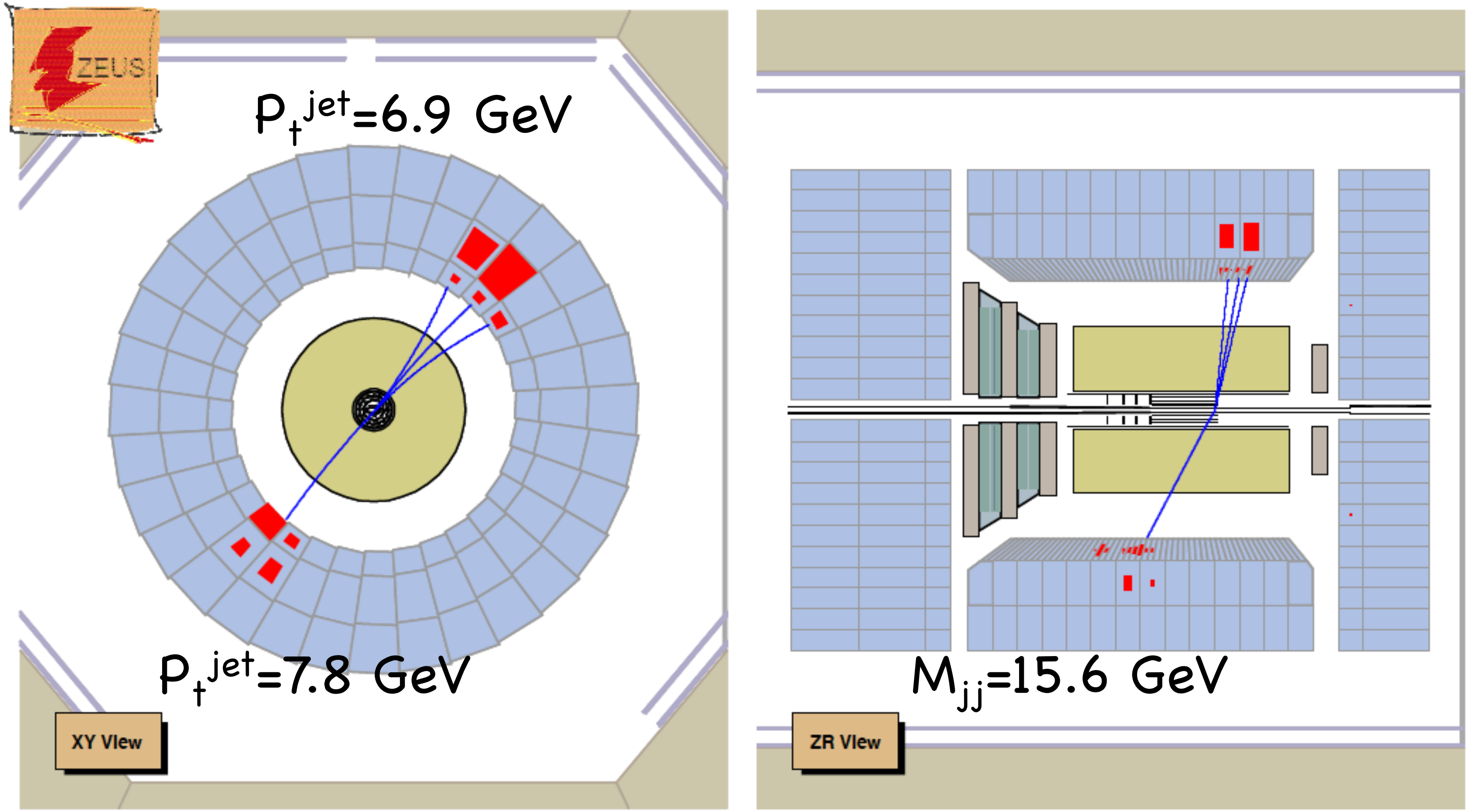
(e)-jet-jet channel

P_t^{jet} > 5 GeV, $|\eta|$<2
The two jets have opposite charge and D>0.8
Main issue: normalization of the dijet photoproduction diffractive background



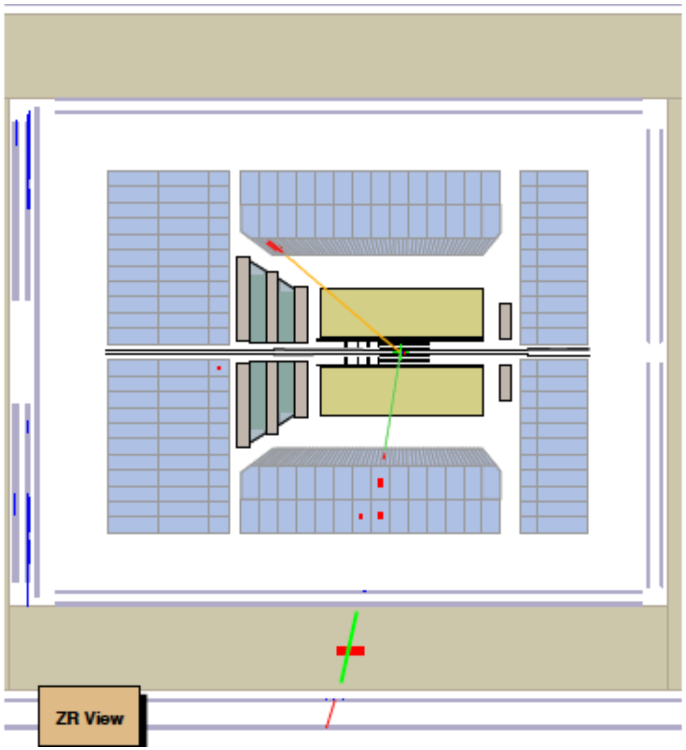


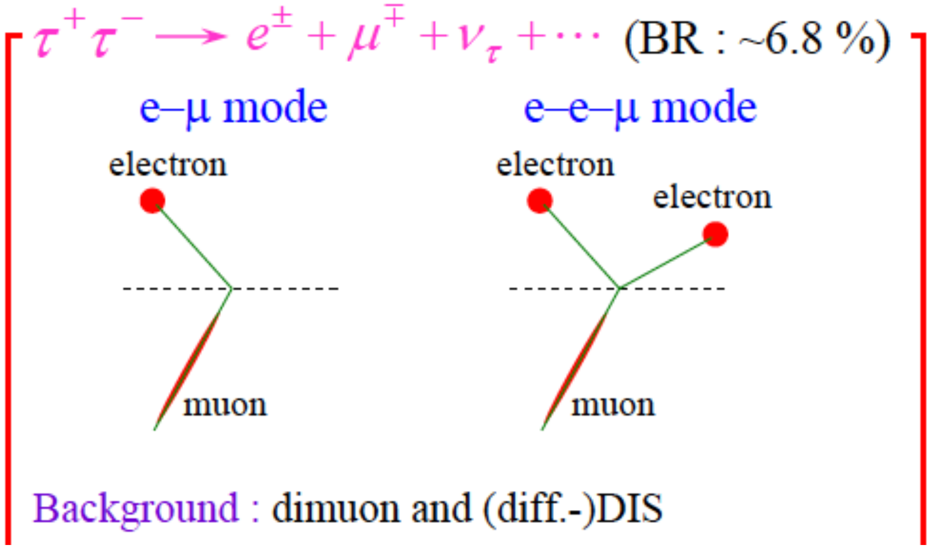
A jet-jet event



(e)-e-μ channel

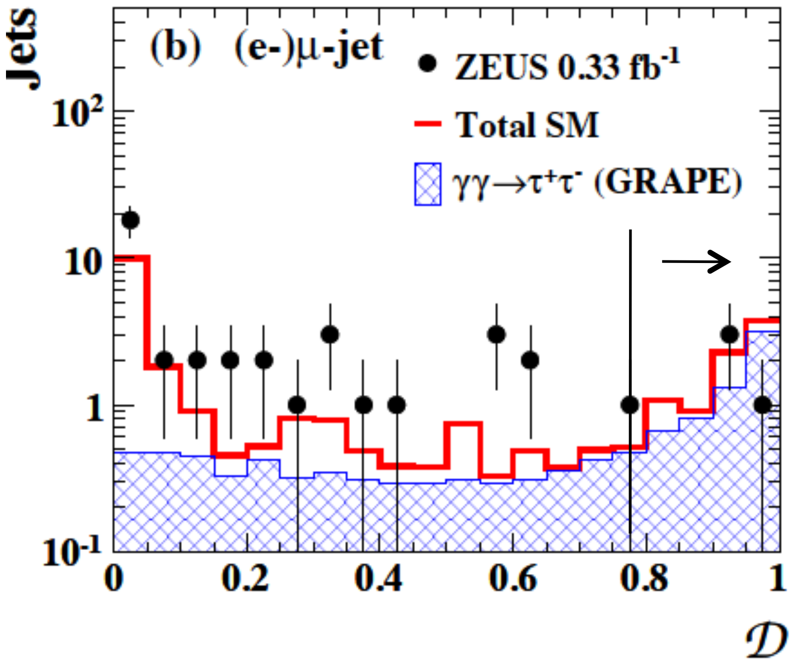
P_t^e > 2 GeV, 17°<θ_e<160°,
P_t^{muon} > 2 GeV,
Main issue: dimuon backg. In e-muon, e opposite charge to the beam



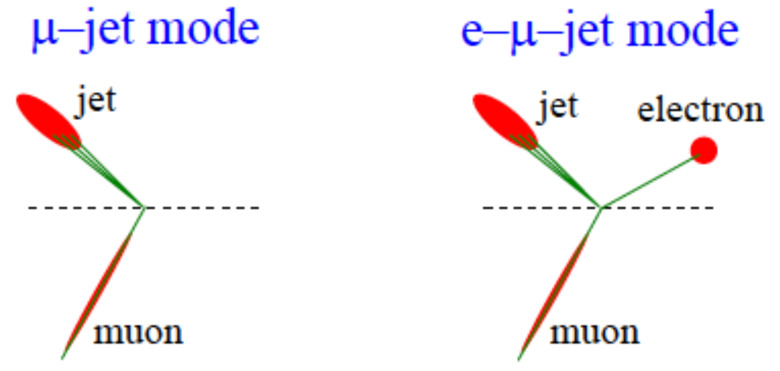


(e)- μ -jet channel

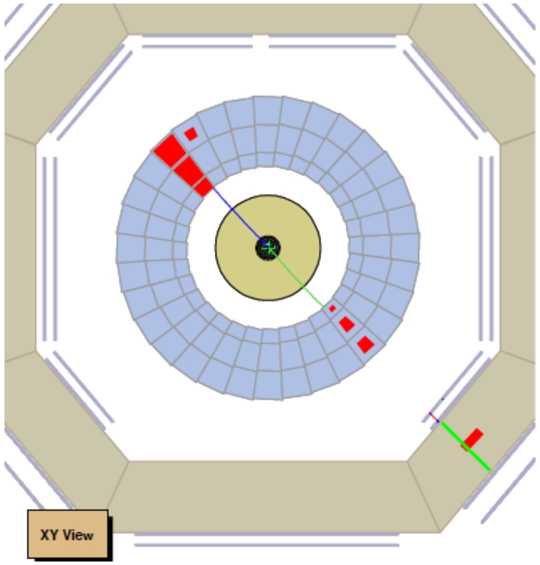
P_t^{jet} > 5 GeV, |η|<2
The jet must have D>0.8



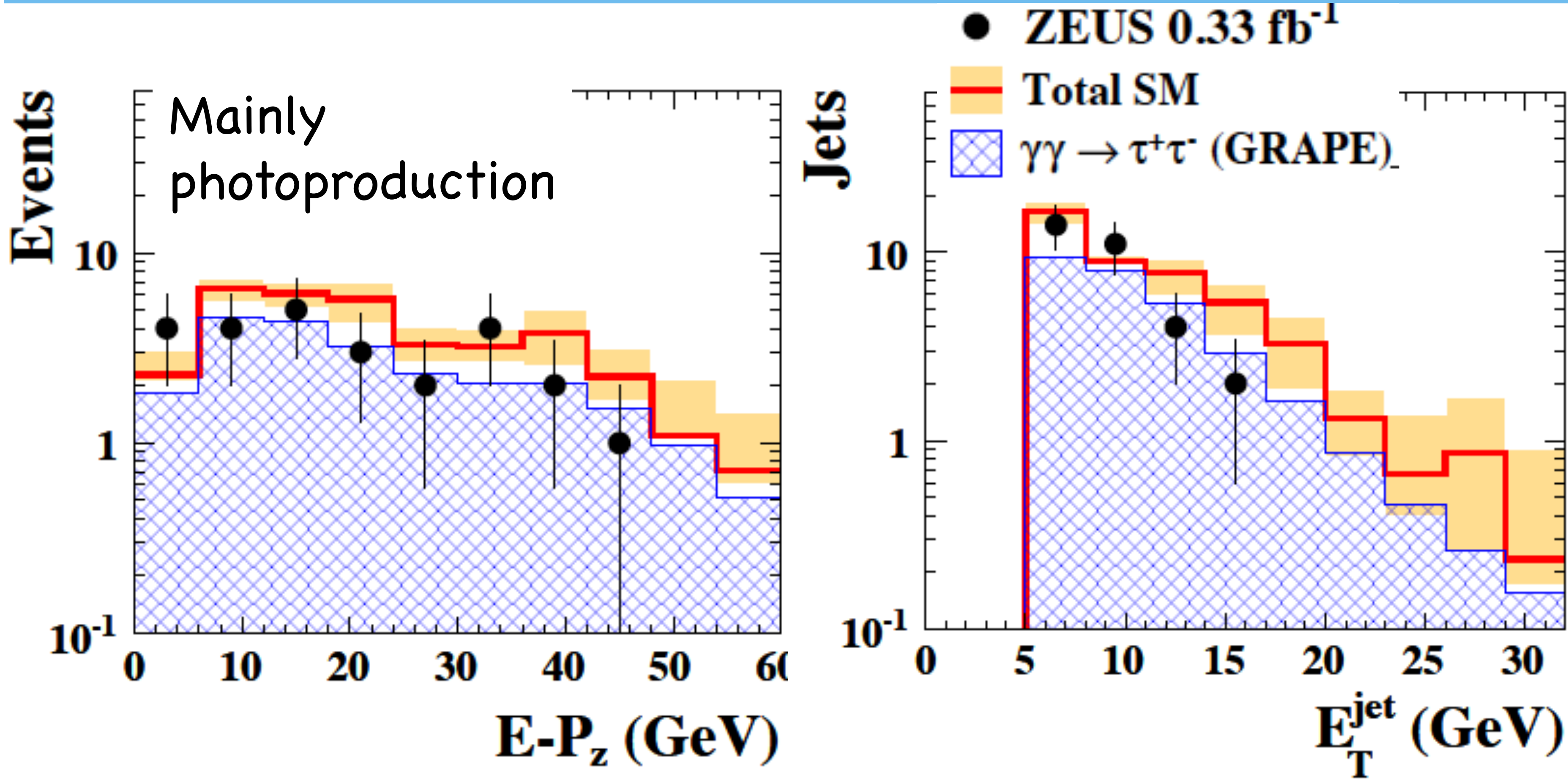
$\tau^+\tau^- \longrightarrow \mu^\pm + h^+ + \nu_\tau + \cdots$ (BR : ~22 %)



Background : dimuon and (diff.-)PHP



All channels



Good agreement with the SM; ratio ditau/total SM shows that purity is high. Jet energy scale dominates the systematics

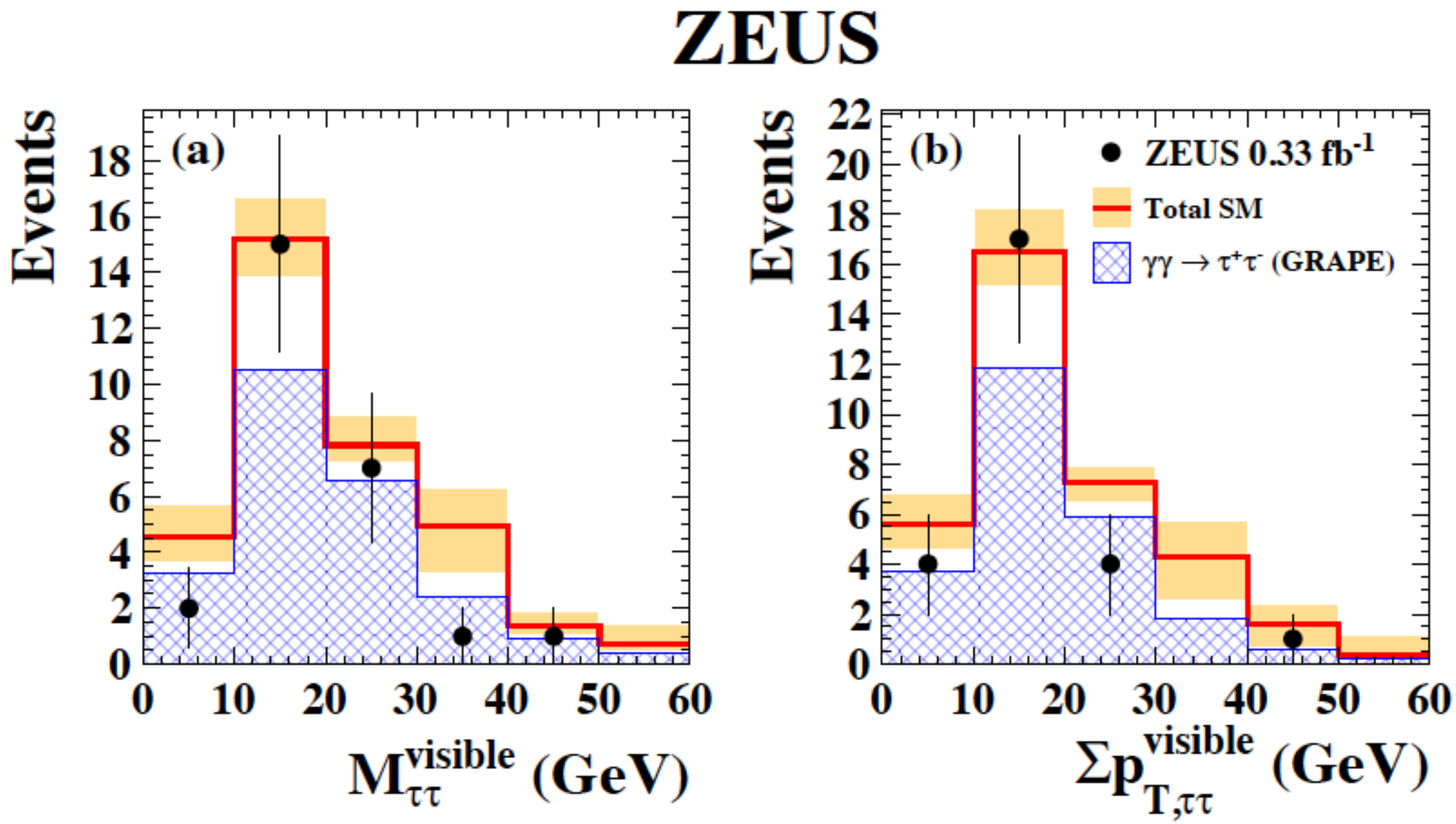
All channels

ZEUS ditau events HERA II data (L=0.33 fb^{-1})

Topology	(e-)e-μ	(e-)e-jet	(e-)μ-jet	(e-)jet-jet	Total
Data	4	7	4	10	25
Total MC	$3.6^{+1.3}_{-0.3}$	$8.8^{+1.8}_{-0.8}$	$8.0^{+2.2}_{-1.2}$	$14.4^{+2.2}_{-3.5}$	$34.8^{+3.9}_{-3.8}$
$\tau^+\tau^-$ MC	$3.0^{+0.3}_{-0.2}$	$5.3^{+0.3}_{-0.2}$	$5.9^{+0.5}_{-0.5}$	$9.0^{+0.4}_{-0.3}$	$23.2^{+0.7}_{-0.7}$
purity	82 %	60 %	73 %	63 %	67 %

One of the smallest sample at HERA and one of the most difficult to select

Results



No surprise at high mass and high total P_t

Summary

- In summary 25 ditau events selected at ZEUS with 67% purity

- The cross section is measured in the kinematic region $p_t(\tau)$> 5 GeV, $17^o < \theta(\tau) < 160^o$ for both τ, (acceptance of 1.23%, due to the p_t cut) :

$$\sigma = 3.3 \pm 1.3\ (\mathrm{stat.})\ ^{+1.0}_{-0.7} (\mathrm{syst.})\ \mathrm{pb}$$

$$(\mathrm{SM}\ \sigma = 5.67 \pm 0.16\ (\mathrm{theor.}))$$